3.—The Plantagenet Beds of Western Australia

By E. de C. Clarke* and H. Tarlton Phillipps

(Department of Geology, University of Western Australia)

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The Plantagenet Beds are horizontal sediments of (?) Miocene age lying on the Pre-Cambrian rocks over an area of at least 14,000 sq. miles along the South Coast of Western Australia. They are commonly about 100 feet thick (max. 300 feet), and the most characteristic formation is spongolite but thin beds of shale and brown coal are known from some localities.

Introduction

During the last hundred years, several writers have mentioned the horizontally bedded sands and clays, seldom apparently as much as 300 feet in total thickness, which overlie the Pre-Cambrian rocks in various places from Albany to Norseman, 300 miles away to the north-east, and along the south coast for 350 miles. Jutson and Simpson (1917) named these undisturbed beds, occurring near Albany, "Plantagenet Beds," "in view of their wide distribution throughout the Plantagenet district", and this name has been universally adopted.

J. W. Gregory (1916) considered that the age of the Plantagenet Beds near Norseman was Miocene. This finding was corroborated by Crespin (Clarke, Teichert, and McWhae, 1948, p. 100). Chapman and Crespin (1934) came to the same conclusion regarding the beds at Albany and Cape Riche. Fossils from other Plantagenet outcrops, as far as they have been authoritatively determined, confirm these findings.

This paper is an attempt to summarize the field and other records of previous observers, and to combine them with notes which we made at various times during the past 25 years. The main object of our visits was the broad study of the Pre-Cambrian rocks, a project for which financial assistance was given by the Commonwealth Research Grant. Our notes on the Plantagenet Beds were therefore rather hurried and casual, but they seem to us to be worth recording, particularly because they will indicate where further detailed work might be done most profitably—and for this reason, we give rather full descriptions of some occurrences. The localities where Plantagenet Beds are known are shown in Plate I and we are indebted to the Chief Draftsman of the Lands & Surveys Department for the drafting of this map.

*Present Address: C/o. Walter Scott, Esq., Te Awamutu, New Zealand.

General character of the Plantagenet Beds

The Plantagenet Beds are a horizontal series of conglomerates, sandstones, and clays overlain by the very characteristic and widely distributed "spongolite" (a sandy or silty rock containing abundant sponge spicules, and occasional entire sponges) in which, here and there, are lenses of limestone. We have not seen any faulting in them apart from displacements of the order of an inch. They lie on a rather irregular basement of Pre-Cambrian rocks, many hummocks and peaks of which project above them. Those peaks of Pre-Cambrian rock which rise to heights of 700 feet or more above the plains may well have been islands in the Miocene sea.

The greatest observed thickness of the Plantagenet Beds is about 300 feet.

Early records of the Plantagenet Beds

Towards the end of 1848 J. S. Roe, Surveyor-General of the colony, led an exploring expedition from Cape Riche (*ca.* 118°45′ E.) to Mt. Ragged (*ca.* 123° 30′ E.). His course, at first, was north-easterly, nearly to the Bremer Range (which he named) about 80 miles north of the coast, thence generally E.S.E. to Mt. Ragged (named, but not visited, a few years before by Eyre) which is about 30 miles north of the coast. He returned in a general westerly direction to Cape Riche, arriving there early in January, 1849.

He wrote that most of the country was densely covered with scrub and "was desolate and cheerless in the extreme", with but few scattered "friendly granite hills . . . which disturbed the uniformity of the horizon like so many bare rocky islands rising abruptly out of the sea". On the outward journey he recorded two separate occurrences of "sandstone", and on the homeward journey, saw many more. He observed that the land near the coast, where composed of this sandstone, "had all the flat-topped appearance" that characterized its occurrence inland.

Later in 1849 F. Helpman and A. C. Gregory further examined the "coal" which Roe had found in the Fitzgerald River, but neither they nor F. von Sommer appear to have added to the information supplied by Roe.

Individual Occurrences

Beginning at Albany and places north of it, we shall describe all known occurrences in succession, travelling eastwards.

In the Albany district Jutson and Simpson (1917, p. 48-50) describe the Plantagenet Beds as horizontal strata of "silt at times cemented into a fine-grained sandstone", but generally only slightly coherent. "Siliceous sponges are especially abundant throughout these beds, many complete skeletons of lithistids being obtainable, whilst isolated spicules of the same and of tetractinellids form an important proportion of the whole rock. In addition, gasteropods, cephalopods, lamellibranchs, and echinoids are found . . .". Two analyses of the white and yellow sandstones (from Cape Riche) are given and the writers note that the beds are characterized by their uniform fine grain, small content of kaolin, almost total absence of calcium or magnesium carbonate, and preponderance of silica, of which a very large part is in the form of sponge spicules. They conclude from palaeontological evidence that the beds are Miocene in age, and that "other fossiliferous rocks of comparatively late age in the southern portion of this State (i.e. those of Lake Cowan*) may ultimately be correlated with the Plantagenet Series".

The Miocene age of the Plantagenet Beds near Albany was later confirmed by Chapman and Crespin (1934).

No one has recorded any contact of these beds with older rocks in the Albany district, or recognized them any farther to the west.

Mr. A. M. Hutchinson, Under Secretary, Water Supply Department, has kindly supplied us with the logs of bores put down in search of water in the plain, which lies to the north of Mt. Manypeak. These show that the plain is underlain by "sandstone" to depths varying from 65 to 300 feet. There is no record of fossils, but we noted fossiliferous Plantagenet Beds on Location 1874, about six miles north-west of Mt. Manypeak.

South and east of the Stirling Range, between the Kalgan and Pallinup rivers, Dr. Robert Smith† describes the Plantagenet Beds as no more than 300 feet thick and lying on a floor of pre-Cambrian rocks. Spongolite is the dominant constituent, but Dr. Smith considers that the salinas and "Yate flats" (swampy ground a few feet below the general level) which are frequent on the plain, have possibly been formed by the solution of calcareous beds.

This plain continues westward, abutting against the south side of the Stirling Range and extending down to the foot of the Porongorups and beyond. Spongolite crops out in several places and Blatchford (1927) states that Plantagenet Beds have been proved to extend to 10 miles north of Cranbrook.

Mr. G. H. Burvill, Commissioner of Soil Conservation, kindly allows us to quote from a MS. catalogue of rock specimens, collected by officers of the W.A. Dept. of Agriculture, from country north of the Stirling Range and south of the branch railway from Tambellup to Ongerup. The catalogue includes several specimens of ferruginous grit, but more significant are an "argillaceous sandstone with sponge spicules" from about 17 miles south-west of Gnowangerup (Loc. 2571), and a sandy shale with a few sponge spicules from about 18 miles south of Borden (Loc. 3933). Blatchford (1930) states that the "Miocene Beds" have been found at Tambellup and Ongerup.

The country from Cheyne Beach inland for about 10 miles is composed "mostly of fine-grained horizontally bedded fossiliferous sandstones—the Plantagenet Beds" (Blatchford, 1927).

Chapman and Crespin (1934, p. 126) identified six species from the sandstone quarried near Warriup Homestead, in the vicinity of which we noted some small crater-like depressions, perhaps due to the former presence of limestone lenses which have been removed by solution.

On the highest part of the ridge overlooking Warriup Creek, about two miles east of the homestead, the old track to Cape Riche passes over horizontally bedded red and green clays which, by aneroid, are about 150 feet higher than the fossiliferous sandstones at the homestead. This is the only exposure which we found of beds apparently overlying the fossiliferous sandstone or spongolite phase of the Plantagenet Beds of which we saw scattered boulders as we descended into the valley of Warriup Creek.

The shallow quarries which yielded the building stone for the homestead at Cape Riehe are in "coherent sandstone belonging to this series" (Jutson and Simpson, 1917) from which about 18 species have been identified (Chapman and Crespin, 1934).

On the left bank of the Eyre River, which enters the sea near the Cape Riche homestead, about a mile above its mouth, is a low cliff of fossiliferous sandstone, the upper part of which is spongolite; the lower part, nearly at sea-level, contains gastropod and pelecypod fossils. This locality might repay examination.

On April 16, 1849, A. C. Gregory rode up the Pallinup River, from its mouth, for about 10 miles. He noted that the banks of the river were of horizontal red sandstones and containing impressions of "corals and shells".

The track from Cape Riche to Chillilup, which is beside the Pallinup River about 15 miles from its mouth, lies over a plain about 350 feet above the sea. From this plain, which has a thin covering of Plantagenet Beds, we saw a considerable area on the far side of the lower Pallinup valley, which seemed to consist of the flat-topped hills and ridges characteristic of Plantagenet country.

The sandy beach at the south-west end of Dillon Bay abuts against the Pre-Cambrian rocks of Cape Knob. The last half-mile of the beach is backed by a cliff, about 60 feet high, the lower part of which is, nearly everywhere, obscured

*See under Norseman in this paper.

† Regional Officer, Division of Soils, C.S.I.R.O., in an unpublished report, from which he permits us to quote.

by blocks of Coastal Limestone which have slipped from above, but, just before the "old rocks" are reached, the whole section is exposed to beach level (Fig. 1).

FIG 1.—Clays and sands underlying Coastal Limestone at Dillon Bay.

The beds, from above downwards, are:—

"Coastal Limestone"	about 30 ft.
Yellow sand	8 ft.
Fine gravel	2 ft.
Mottled red and green sandy clay	5 ft.
White clayey sandstone, fossiliferous,	1 ft. 6 in.
Clay	6 in.
White clayey sandstone, fossiliferous,	1 ft. 6 in.
Yellow incoherent sandstone	3 ft.
Beach	

The age of the lower beds is not known for their fossils have not been thoroughly examined. A rather irregular surface seems to separate them from the Coastal Limestone (generally regarded as Pleistocene) and we suggest that these lower beds may be correlated with those, mentioned later, which occur at or below sea-level at Duke of Orleans Bay.

Jutson and Simpson (1917, p. 50) note that a specimen of *Aturia australis* McCoy was determined "by L. Glauert in undoubted spicular silt of the Plantagenet Series from the Bremer River" which runs into Bremer Bay.

Fossiliferous horizontally bedded sandstones and clays form the steep right bank of the Gairdner River about half a mile south of Quaalup Homestead, and also a cliff about 80 ft. high on the left bank, about three-quarters of

FIG. 2.—Cliff of Plantagenet Beds at Marlamerup Crossing, Gairdner River.

a mile north-east of the homestead. Fossils occur at various heights in the cliff, but are most abundant at a horizon which is level with the bank from which we collected south of the homestead. Here, as elsewhere near Quaalup, secondary silicification and removal of the carbonate make it difficult to get good specimens. Miss Irene Crespin has identified *Cellepora coronopus* from among the bryozoa, which are the most abundant fossils. She also notes the presence of a club-shaped cidaroid spine like one described by Chapman and Cudmore (1934, p. 142). A single specimen of a nautiloid was found by Dr. Curt Teichert to be "fairly close to the Victorian *Nautilus balcombensis* Chapman or *Nautilus geelongensis*."

At Marlamerup Crossing on the Gairdner River, about eight miles west-north-west of Quaalup and 13 miles from the mouth of the river, the right bank is composed of horizontal beds which form a cliff about 100 feet high. The lowest bed is a poorly consolidated conglomerate consisting almost entirely of subangular quartz pebbles. Above this are clayey beds with obscure remains—perhaps of bryozoa and calcareous algae. This occurrence should be more closely examined.

Similar rocks form bluffs on the left bank seven and 11 miles up the river from Marlamerup—the last-named locality is near Wellstead's homestead.

Between these occurrences on the Gairdner River are many outcrops of Pre-Cambrian rocks, which are also common on the higher ground north-east of the river.

The point just north of the "Boat Harbour" at Point Ann is composed mainly of large slabs, some of unmetamorphosed breccia, others of grit. Some of the boulders in the breccia are four feet long; nearly all are of cellular-weathering quartzite, which we did not notice in the Pre-Cambrian rocks of Point Ann. A mudstone seems to underlie these breccias. This occurrence is unique in our experience of this part of the State and may not belong to Plantagenet times.

Horizontally stratified ferruginous sandstone overlies micaceous sandstone four miles up the St. Mary River, which enters the sea a little north of Point Ann. These are probably of Plantagenet age and, if so, were deposited in a Miocene inlet bordered by Pre-Cambrian rocks which outcrop nearby and farther down the river.

The "estuary" of the Fitzgerald River, like nearly all the "estuaries" on the south coast, is a flat, the lowest parts of which are usually covered with a thin sheet of water. Much of the Fitzgerald estuary is, like the river upstream, bordered by cliffs of horizontally bedded sands and clays often 100 feet or more high. The cliff (Fig. 3) near the old Ravensthorpe-Albany track, about eight miles inland from the sea, rises 130 ft. above the wide river flat which is an insilted part of the estuary. From the base for 45 feet is a talus slope; the next 34 feet is of a sandy micaceous clay with occasional yellowish partings and irregular yellow patches; the top 50 feet is of less clayey material. No fossils were found throughout the section.

FIG. 3.—Cliff of Plantagenet Beds on south side of Fitzgerald River.

Dempster Inlet opens to the sea about three miles north-east of Fitzgerald Inlet. On its south side, about two miles from the sea, conglomerate and red sandstone, overlying Pre-Cambrian rocks, come down nearly to sea-level. These probably belong to the Plantagenet Beds.

Plantagenet Beds first appear in the upper Fitzgerald valley, according to Mr. A. F. Wilson, about seven miles below the crossing of the Ravensthorpe-Ongerup road, where a fairly thin layer of them rests on the "old rocks". Ten and a half miles farther east on the road, horizontally bedded clayey grits and clay form a bank 15 feet high on the side of a stream. They lie on a "granite" floor and may be Plantagenet Beds. The thickness of the beds increases steadily downstream on the Fitzgerald, reaching more than 300 feet about six miles above the "coal" seams on both the Susetta and Fitzgerald. In both valleys, but especially in the Susetta, the Plantagenets are seen in places to rest unconformably on the "old rocks". The basal bed, varying in thickness from a few inches to many feet, is moderately coarse ferruginous sandstone, composed mainly of quartz grit cemented with iron oxides. In the Susetta it rests on at least 30 feet of highly kaolinized granite which seems to indicate that the Plantagenet Beds in that area were laid down on an old land surface. In the Fitzgerald River, on the other hand, they lie on a smooth surface of unweathered granite with a certain amount of, probably re-arranged, decomposed granite in its hollows.

The Plantagenet Beds in the Fitzgerald basin are much banded, the bands varying from a fraction of an inch to many feet in thickness. Along the Fitzgerald and Susetta there is generally a well-defined colour-change about halfway up the cliff.

The chief object of Roe's expedition in 1848-9 was to report on the Fitzgerald "coal", which, it was rumoured, had actually been used by a French whaler. Roe spent about three days in December, 1848, in and near the river valley. On December 27th he found "coal" in the Elwes branch. The part exposed was "12 to 15 yards wide and 61 yards long", but there was evidence that it extended farther. "It seemed to be horizontal" but the "shales" on the right bank of the river dip south-east at 45° and "are exactly the same as those on the Phillips River." (These "shales" are weathered Pre-Cambrian schists; they are often mentioned by Roe and A. C. Gregory (1849)—Gregory correlated them with the Permian shales of the Irwin River, in which he had discovered coal in 1846). Roe dug into the "coal", which was like "carbonized wood resembling pine. Elongated globules of bitumen from the size of a pea to that of a goose egg were found in it." In journeying round the Fitzgerald basin, he noted the wide development of horizontally bedded sandstones, which in many places formed cliffs 80 to 90 feet high.

He travelled southward from the Fitzgerald to the Gairdner River, passing to the inland of West Mount Barren, and noted "well-defined brown sandstone cliffs 80 or 90 feet high", at the foot of which the country was "very rocky" (no doubt Pre-Cambrian).

Blatchford (1930) states that the Plantagenet Beds occur extensively in the Fitzgerald River valley and form a strip a few miles wide immediately north of the Barrens. He considers that they were originally at least 1,000 feet thick. Our route through this strip lay close to the "old rocks" of Middle Mount Barren and we failed to notice any Plantagenet Beds, except at its eastern end, where we collected from a richly fossiliferous spongolite. Many years ago Blatchford made an extensive collection of similar material about one mile north of where the Hamersley River crosses the telegraph line Here, according to Blatchford (1919), a breakaway teems with fossils, chiefly sponges, probably of Tertiary age. The locality described by Blatchford is three miles or more west from where we collected the material which has recently been described by de Laubenfels (1953). As supplied by us to Professor de Laubenfels, the locality is 20 miles south of Ravensthorpe —for future workers in the field we may describe it more precisely. The former road from Albany to Ravensthorpe keeps as near as is practicable to the telegraph line to South Australia (dismantled some years ago). Approaching the Phillips River, near the foot of the Eyre Range, about 4¾ miles before the line crosses the river, and about 7¾ miles north of the mouth

FIG. 4.—Roe's Rock, a mesa in Plantagenet Beds, approximately 20 miles upstream from the mouth of the Fitzgerald River. (Photo A. F. Wilson)

of the Hamersley Inlet, the old road turns north-east and passes close to the fossiliferous spongolite, which forms a steep reddish slope (Fig. 5).

FIG. 5.—Flat-topped bank of spongolite containing many more or less complete sponge skeletons. Taken from near Phillips River on old track from Albany to Ravensthorpe. Eyre Range of Pre-Cambrian rocks in background.

On the Phillips River, about three miles north-west of this locality is a red bluff of coarse sandstone overlying white shales. These horizontally bedded rocks overlie contorted weathered schists.

In January, 1924, one of us (E. de C. C.) accompanying the late Mr. H. P. Rockett, Inspector of Mines, visited an old quarry, from which sawn blocks of spongolite were taken, it is said for use in the former copper ore smelters at Ravensthorpe. The spongolite in this quarry is apparently underlain by sandstone and both rocks are horizontally bedded. The quarry is about half a mile west of the old road from Albany to Ravensthorpe and about 11 miles from Ravensthorpe.

About 60 miles north of Ravensthorpe and 40 miles south-west of Bremer Range, on November 1st, 1848, Roe "travelled for half a mile on a low level bed draining to the east". It was "600 yards wide with well-defined, water-worn banks". The "red and white sandstone banks" of this channel were 15 feet high and the sandstones showed no "dip or inclination nor did we see them again as we went north-east".

On and near the Ravensthorpe-Esperance road, between the Munglinup and Young Rivers, are several exposures of Plantagenet Beds; in one, about four miles east of the Munglinup, obscure fossils and an echinoderm spine occur in mottled green and yellow clay and, two miles west of the Young River crossing, lumps of spongolite lie on the side of the road.

Half-a-mile to the north of the road, just east of the Lort River, is a very conspicuous white patch—a low cliff, probably a clayey phase of the Plantagenets, which, judging by the level of the spongolite farther back on the road, must underlie the spongolite. The road here runs for some distance on a thin platform of Plantagenet Beds lying on an irregular surface of gneiss.

Roe, on his homeward journey in December, 1848, travelled near the coast from the site of the future Esperance to the Phillips River. On December 10th he came to an "open deep river, 15 yards wide, bordered by steep yellow and red cliffs, indicating the proximity of the coal formation". Mr. L. Glauert tells us that he has recently received a fossil nautiloid said to have been found "at Dalyup".

On December 12th Roe recorded "white, yellow, and red cliffs" resting on "granite or gneiss", probably near Barker Inlet. He remarked that, above the "deep open reach, more

than 250 yards across, the level on either side of the valley had all the flat-topped appearance of the sandstone formation, but granite and gneiss was the prevailing rock at the lower levels". Ten miles inland from the mouth of Stokes Inlet, he saw fragments of red sandstone with many "perfect impressions of bivalve shells", and from here to the Phillips River he found many occurrences of the "red sandstones".

Spongolite containing a few molluscan fossils occurs on the track from Esperance to Cape Le Grand, about six miles north of Frenchman Peak. In the creek which drains from Frenchman Peak into Esperance Bay a horizontally bedded clay overlies more than six feet of unconsolidated sand. If these are part of the Plantagenets they must underlie the spongolite seen at a higher level on the track.

Roe gives his position on about November 12th, 1848, as lat. 33° 8′ S., long. 121° 52′ E. He must therefore have been in what was later known as the Salmon Gums district. Here he passed over the "dry beds of several salt lakes formed of the white and dark-red sandstone belonging to the coal formation. They were very mottled and confusedly mixed and had numerous veins of very hard ironstone running through them, similar in appearance to the sandstone which we afterwards saw in close connection with coal and shales".

Burvill and Teakle (1938) noted that, in this district, "marine sediments, of which a spicular sandstone is representative, certainly occur, and may be observed in exposures around numerous salt lakes. Borings to 15 to 20 feet, in areas of the Circle Valley sand, have encountered a similar sandstone."

Flat boulders of greenish, carbonaceous, fossiliferous shale with chalcedonized patches, occur on the sandy beach of the eastern part of Duke of Orleans Bay near High Island. Higher up, on the track leading down to the bay, boulders of spongolite are seen. The shale must be *in situ* to below high-water mark, but probably only to a shallow depth, for High Island and the western part of the bay are of Pre-Cambrian rocks.

Ten miles north-east of Duke of Orleans Bay, at the crossing of the Mungliginup Creek and 200 feet above sea-level, very fossiliferous spongolite is exposed. The country, practically level here, is covered by only a thin layer of Plantagenet Beds, for the track, after passing for about three miles over occasional spongolite outcrops, lies for eight miles over granitic or gneissic rocks after which it crosses sparsely fossiliferous spongolite with chalcedonic nodules and streaks.

In the valley of the Thomas River, at the deserted homestead Lynbourne, limestone with a botryoidal crust of travertine is underlain by a greenish-grey clay. These beds apparently underlie a fossiliferous bed containing "Pecten", which outcrops 3½ miles down the valley at 180 feet above the sea.

Spongolite outcrops were noted on the plain, at 270 feet above the sea, immediately after ascending from the Thomas valley east of Lynbourne, also beside the Israelite Bay track eight miles east of the Thomas River. This is 50 miles or so west of the western edge of the Eucla Artesian Basin, which is composed of Miocene limestone, practically horizontal, and lying on a floor of granitic rocks.

We did not recognize Plantagenet rocks east of the last-named occurrence, but Maitland (1925, pp. 4 and 5) when describing the country "in the vicinity and to the north-west of Israelite Bay", referred to the "salt lakes", along the shores of which are horizontal beds of gritty ferruginous sandstone. In other places, "quasi-vitreous quartzites" occur. These beds, which we did not see, he considered to be probably remnants of the "Plantagenet (Miocene) Beds".

Conclusion

Although we have not contributed any new general facts about the Plantagenet Beds, we may here summarize conclusions, already drawn elsewhere, as to conditions in part of the south of Western Australia in Miocene times.

A thin series of horizontal sediments lies on the Pre-Cambrian rocks over an area of at least 14,000 square miles (or half the area of Tasmania) in part of south-western Australia. Spongolite is nearly everywhere the upper layer of this series. Various bryozoan, molluscan, and other fossils occur rather sparingly in the spongolite, but, notably in the north, near Norseman, and in the south, at Quaalup, there are shell beds apparently of small extent laterally. The bryozoa and mollusca fix the age of these Plantagenet Beds as Miocene. The sponges, chiefly those from a place near the coast, have recently been examined by Professor de Laubenfels, who finds that all identifiable forms are lithistids "which would seem to indicate a depth" of the sea in which they lived "of 20 to 200 meters". He states that today sponges are most abundant in estuaries just far enough out to sea for complete oceanic salinity to be established and far enough from the land to be free of coarse detritus, but not of fine silt which accumulates round the sponges. He therefore concludes that the region was, when the fossils were living, just off shore from a river—the bigger the river, the farther off shore. He discusses Hinde's (1910) paper on the Norseman sponges and concludes that "no genera can be regarded as conclusively identified in Hinde's paper, and only a few are even probably identified" (de Laubenfels, 1953, p. 115).

The Plantagenet Beds are everywhere horizontal, and, although the spongolite is little above sea-level near the coast, near Norseman, about 100 miles inland, it is nearly 1,000 feet higher. It would seem then that, during the maximum Miocene submergence, the sea extended over the greater part of what is now southern Western Australia, and that conditions favourable for the lithistids gradually moved south with the slow rising of the land (or fall of sea-level). Here and there, as the coastline moved south, shell beds flourished in the shallower water.

This reconstruction of Miocene events has already been suggested by Clarke, Teichert, and McWhae (1948).

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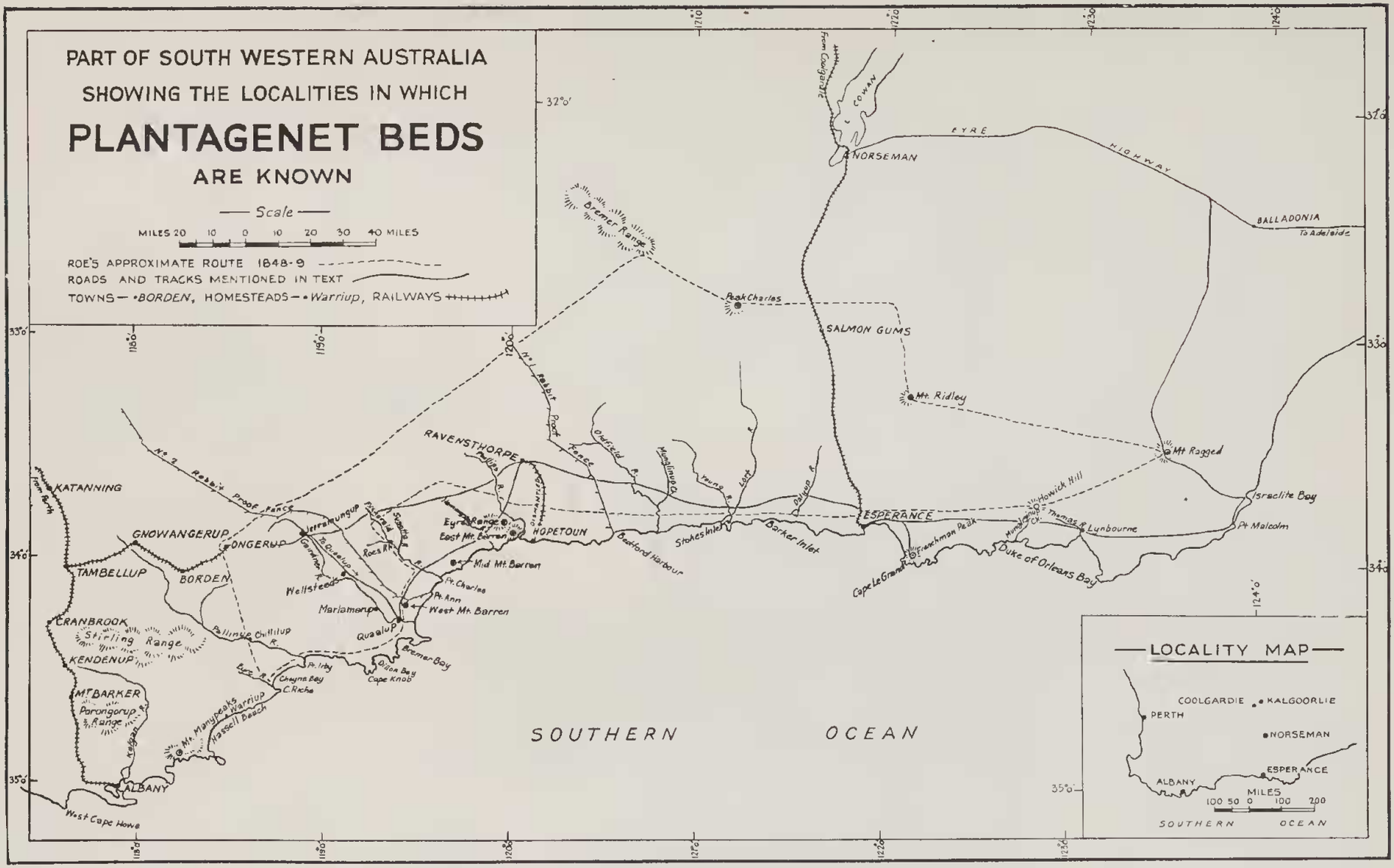

PLATE I.—Map of part of Southern Western Australia showing the localities in which Plantagenet Beds are known.